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# The Carbon Footprint of Attica Tollway

Dimitris Mandalozis[a,*], Bill Halkias[b], Helen Tyrogianni[c], Natalie Kalfa[d]

[a]*Strategic and Organisational Manager, 41, 9Km Attiki Odos, 19002, Greece*
[b]*CEO, 41, 9Km Attiki Odos, 19002, Greece*
[c]*Head of Consulting Services, 41, 9Km Attiki Odos, 19002, Greece*
[d]*Civil Engineer- Transport Planner, 41, 9Km Attiki Odos, 19002, Greece*

**Abstract**

Climate change is the major global environmental issue that businesses of all sizes have to face. With the effects of global warming becoming irrefutable, customers and external stakeholders are expecting businesses to act responsibly and take action to reduce and compensate for their respective impacts on the environment.
Attica Tollway constitutes the ring road of the city of Athens, a 70 kilometre-long, fully access-controlled toll road, which was also the first BOT road project in Greece. Its development faced significant difficulties because of the complexity of constructing a motorway in a dense urban area, within a limited expropriation area and with acute traffic problems prevailing in the surrounding network. However, difficulties were overcome and the success of the project has exceeded expectations, since current average daily traffic volumes of more than 280,000 vehicles are surpassing the original predictions.
Environmental management was incorporated into the early stages of design and construction of Attica Tollway, in order to mitigate impacts on the environment and to bring environmental and social benefits to the surrounding areas. The project has been developed to fully comply with Greek and EU environmental standards and guidelines.
Attica Tollway considers carbon footprint assessment to be a very powerful tool in understand the impact of the tollway's operational activities on global warming. With this in mind, the company successfully carried out the calculation of its carbon footprint and then proceeded to take mitigation measures, such as the use of photometers, renewal of its fleet with more environmentally-friendly vehicles etc. In parallel, these measures contributed significantly to cost savings.



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* Corresponding author.
*E-mail address:* dmandalo@attikesdiadromes.gr


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## 1. Introduction

A few decades ago, climate change and global warming were only known and discussed among academics, with various specialists making different forecasts as to what is going to happen in the future. However, as the years have gone by, the various climatic changes and effects of global warming have slowly but steadily reinforced some of the original theories relating to what is going to happen to our planet, if we do not change the way we live and do business.

So, today, hard-core facts show that the temperature of our planet has been rising over the past 100 years and the earth will "heat up" by another 4°C by the end of the century if we continue with "business as usual". Biodiversity is under threat, with different species of flora and fauna at the threat of extinction, while our water resources are being contaminated and are running short. The viability of our planet as a whole has been severely compromised and our future is under significant threat. Climate change is a major global environmental issue that we all have to face

The Kyoto convention in 1998, which led to the signing of the Kyoto Protocol, where countries agreed to reduce their emissions of 6 major greenhouse gases from specific business sectors, has led to a new way of living and doing business, by setting a new trend: that of reducing GHG emissions. Since then, customers and external stakeholders have been exerting increasing pressure on businesses, expecting them to act responsibly and take action to reduce and compensate for their respective impacts on the environment.

Even if the transport sector is not one of the sectors were specific actions have to be taken to reduce GHG emissions, according to the Kyoto protocol, is it only a matter of time until it, too, will have to set specific targets and take strict mitigation actions to reduce its effect on the planet. So, if it is not compulsory yet, why should companies and businesses of the transport sector bother with emissions and carbon footprints etc? Volunteering to investigate the effects of a company's activities indicates a company that is responsible and that takes sustainable development into serious consideration.

Sustainability requires the reconciliation of environmental, social and economic demands - the "three pillars" of sustainability- which are interdependent and affect one another directly or indirectly. For example, when one addresses the environment, one cannot ignore the effects that global warming has on world economy or on our individual lives and our health, not to mention the effects on future generations. So, in effect, being proactive about greenhouse gas emissions, even if it is not obligatory so far, can only bring benefits to a company, with significant financial savings, as well.

## 2. Global warming and carbon footprint

The greenhouse effect occurs when carbon dioxide ($CO_2$), along with methane gas ($CH_4$), nitrous oxide ($N_2O$), hydro-fluorocarbons (HFC), perfluorocarbons (PFC), sulfur hexafluoride ($SF_6$) and ozone (O3), cause the heat (from the sun) to get trapped between the surface of the earth and the troposphere and not escape in space. Hence, an increase in the concentration of the greenhouse gases brings about the increase of the earth's temperature (global warming), which, in turn, yields climate change.

Every human activity is ultimately linked with the production of greenhouse gases, which is measured as concentrations of each type of gas, or standardized to carbon dioxide equivalents. Carbon dioxide equivalency is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of $CO_2$ that would have the same global warming potential (GWP - a relative measure of how much heat a

greenhouse gas traps in the atmosphere), when measured over a specified timescale (generally, 100 years). Hence, every organism, action or product can be described in terms of its carbon footprint, which is the total of the greenhouse gases – standardized to carbon equivalents - that are produced in relation to it.

Climate change is the major global environmental issue that businesses of all sizes have to face. With the effects of global warming becoming irrefutable, customers and external stakeholders are expecting businesses to act responsibly and take action to reduce and compensate for their respective impacts on the environment. This paper presents the methodology and results of Attica Tollway's efforts to estimate and reduce its carbon footprint.

## 3. Attica Tollway – an environmentally-conscious motorway

Attiki Odos Motorway (also known as Attica Tollway) is a modern, 65m long, urban-peripheral motorway forming a ring road around the city of Athens, Greece. It is a closed-toll motorway, with two directionally separated carriageways (3 lanes plus an emergency lane each), 39 toll stations and 195 toll lanes, and the first Road Concession Toll Road Project in Greece. Attica Tollway is also one of the first toll motorways ever to be opened to traffic in a major metropolitan capital city, and, more specifically, Athens, a city that is densely populated, with lots of history, but also with many environmental challenges.

The main purpose of Attica Tollway was to alleviate the heavy traffic congestion problems of the greater metropolitan area of Athens and to improve accessibility to areas around the capital. In addition, the motorway was built with great respect for the natural and urban environment and full harmonization with the surroundings, so as to protect the already environmentally-challenged Attica region, but also maintain the quality of life of the people living near the Tollway. To date, the project has exceeded expectations, since current average daily traffic volumes of more than 280,000 vehicles are exceeding the original predictions and environmental management has ensured the operation of a "green" tollway.

As a result of these continuous efforts in environmental management, Attica Tollway received the 1st Prize for Environmental Mitigation from the International Road Federation (IRF) in 2008. Furthermore, the company is certificated with the ISO 14001: 2004 for its Environmental Management System, which is applied and updated thoroughly. Since for the people in Attica Tollway, the mission is to ensure high-quality innovative services that may extend beyond any contractual obligation, such awards and certifications are important, but are not enough. Thus, in an attempt to go beyond contractual obligation with regards to the environment and to keep up with the constantly increasing requirements towards environmental protection and sustainability, the company decided to proceed with the calculation of its carbon footprint.

## 4. Carbon footprint calculation – Why?

Attica Tollway considers carbon footprint assessment to be a very powerful tool in understanding the impact of the tollway's operational activities on global warming. Despite the fact that the transport sector is still not included in the carbon market, the company, trying to remain proactive in issues regarding the environment, commenced the carbon assessment process early, remaining true to its corporate social responsibility policy and its clients, both internal (employees) and external (users). Apart to the direct impact to the environment and the reduction of emissions, carbon assessment will serve as a valuable tool for the education of both the company's employees, as well as the Tollway's users. The employees will have the opportunity to acquaint themselves with the processes involved in carbon assessment early enough, so that when carbon assessment becomes compulsory for the transport sector, Attica Tollway will be well-prepared and well ahead. As far as the users and the general public are concerned, carbon

assessment will serve as a good opportunity for education and initiation of similar behavior, showing what good practice is and what could be applied on our everyday lives.

One of the main benefits of carbon assessment is the fact that it can put all environmental actions into perspective and it can reveal which actions have the most effect on GHG reductions, without necessarily being the most costly or the most complex. Estimation of carbon emissions is essential, as it is impossible to take actions to reduce something that has not been measured before. We may know that certain actions help towards emission reduction, but only through carbon assessment can we be able to determine the exact effect of this action.

## 5. Carbon footprint calculation – How?

For the assessment of Attica Tollway's carbon footprint, after reviewing the various methods available, the method "Bilan Carbone®" was chosen. This tool offered simple processes for quick calculations, enabling the company to assess its business activity data (such as energy bills, amounts of raw materials purchased, km travelled, etc.). The greenhouse gas emissions were estimated in tonnes of carbon equivalent, item by item, category by category. The first calculation of Attica Tollway's carbon footprint was carried out for the year 2009, which will serve as the base year in all future estimates. This effort was carried out with the guidance of the French Shareholder of Attikes Diadromes, Egis Road Operations.

As far as the carbon footprint calculation for Attiki Odos is concerned, direct energy consumption, employee and visitor travel, incoming freight transport, purchased services and amortizations were the main categories of GHG emissions that were considered, in full knowledge that the results will only concern Attica Tollway and will mainly serve as a basis to quantify the effects of actions that will be taken for the future years.

### *5.1. Bilan Carbone® - the tool*

There are many different carbon assessment tools available currently, with similar methods of calculating the GHG emissions. In effect, they all have a way of breaking down the different activities carried out in a company and allowing the user to feed in the necessary information in various ways (quantities, estimates etc). For the purposes of the carbon assessment for Attica Tollway, the Bilan Carbone® tool was used, as can be used to account for the greenhouse gas (GHG) emissions of all types of organisation: industrial or tertiary companies, administrations or local authorities.

The tool offers simple spreadsheets for quick calculations that enable you to process the most of business activity data (energy bills, amounts of raw materials purchased, km travelled, etc.) The greenhouse gas emissions are estimated in tonnes carbon equivalent, item by item, category by category.

It is important to understand that both direct and indirect emissions are taken into account. Take for example a personal computer: its energy consumption has a direct impact, but we should not forget that GHG were also emitted for its design, its building and transportation (indirect emission). The emission factors take all that into account, from cradle to grave.

All the greenhouse gas emissions linked to the company's activity are taken into account. The broader the evaluation, the more scope you have for action, and the greater the benefits to be gained from your forward-looking decisions. This method, which has been developed by ADEME, is compatible with standard ISO 14064, the GHG Protocol initiative and the terms of the "permit" Directive No. 2003/87/CE relating to the $CO_2$ quota trading system.

The Bilan Carbone® module is made up of:

- A main Excel spreadsheet called the master-sheet which is ready to sue to calculate emissions, compare emissions between different years and assess the potential of various reduction actions
- A first utility, which is specifically provided to help users calculate the tonnes per kilometre involved in road transport
- A second utility dedicated to calculating cooling gas leaks from refrigeration and air conditioning systems
- A third utility intended to enable users to use the results in the main spreadsheet by simulating "what's at stake economically" over the entire activity studied if the cost of fossil fuels increases or if a tax on GHG emissions is introduced.

*5.2. Methodology*

For the first estimation of the carbon footprint of Attica Tollway, data from 2009 was used. It is important to stress that carbon footprint calculation is not an accurate calculation and its results cannot serve as a basis for comparison with the results of calculations for other companies etc. The results are only useful for the particular company or entity that undergoes carbon assessment and they serve as a basis of comparison from one year to the other, to see how different actions affect the company's footprint.

There are so many aspects of a company's daily operation that can go towards carbon footprint calculation. The bigger the company, the more complex the data and the processes associated with deriving this data. However, depending on this data, it is not mandatory to include everything in the estimate of the carbon footprint, especially if some aspects are very difficult to control or even alter in such a way, so as to bring about significant reduction of the carbon footprint.

With the above in mind, we initially considered everything that is actually necessary to run the business, including activities that are governed by the stakeholders, such as:

- Visitor travel and
- Purchased services (invoices, breakdown assistance, etc),

provided that could make reasonable assumptions and give the best possible estimate for each item when using the Bilan Carbone tools. If we could not obtain useful data, we had to exclude the item from our calculation, as it would be something that would be very difficult to estimate in the following years as well, and something that the company had very little control over, so as to include it in its carbon-reduction plans.

For the year 2009, we targeted the data shown in the Table that follows. « OK » stands for data that could be used directly for the assessment, « C » indicates that extra calculations or estimations were made prior to the assessment, « - » indicates that the data could not be collected or processed, but was neglected according to a sensitivity test. (The following section, 5.3, gives more details regarding the type of data that we had to gather and calculate/estimate what was required in the calculation tool.)

| | | |
|---|---|---|
| **Direct energy consumption** | Fossil fuel consumption for space heating | OK |
| | Electricity consumption for heating and other specific uses (computers, office lights, office equipment, etc) | OK |
| | Electricity consumption for tunnels, lightning, water treatment | OK |

| | | |
|---|---|---|
| | Refrigerant fluids consumption for air conditioning | - |
| **Freight** | Internal freight : dedicated messenger for documents and administrative uses | - |
| | Incoming freight: identification of main suppliers of office supplies (small supplies, paper, miscellaneous, etc) | C |
| **Passenger transport** | Home-Work travel by employees | OK |
| | Outside travel by employees | OK |
| | Travel by visitors | C |
| **Incoming materials and tertiary services** | Office supplies (small supplies, paper, miscellaneous) | - |
| | Purchased services | C |
| **Amortizations** | Buildings and parking areas | C |
| | Computer equipment | C |
| | Machinery and vehicles | C |
| **Waste treatment** | Waste collected and treated | C |

The calculation tool includes a wide database of emission factors. This database has been established through an iterative number of workshops and upgrades, the process being coordinated by the National Environment and Energy Agency (Ademe) of France. An emission factor expresses the amount of GHG related to a specific good or service, including the « grey energy », the hidden energy due to the manufacturing, for instance.

Emission factors can be labelled in t.C-equivalent or $t.CO_2$-equivalent, where 1 $kg.CO_2$-e = (44/12) kg.C-e = 3,66 kg.C-e. We chose to use $CO_2$-e for our calculations, and some examples of factors that were used in this assessment are shown below:

- Electricity : 1 kw.h = 0,725 $k.CO_2$-e
- Paper : 1 t = 1,32 $t.CO_2$-e
- Pesticide : 1 t = 25,66 $t.CO_2$-e
- 1 km by car on suburban roads : 322 $g.CO_2$-e
- Amortization of a personal computer over 3 years : 1,28 $t.CO_2$-e

The Bilan Carbone® tool provides several means of calculation for a particular item. Obviously, the most straight-forward way is to input a metric value (kw.h, km, ton, etc.) and to use emission factors to establish the corresponding carbon dioxide equivalent. However, when this is not available or too complicated to measure, an alternative emission factor can often be used, such as an amount of money or a number of items (example: number of computers, man-hours, etc). The next chapter details how the available data was processed.

### *5.3. Data processing*

Table 1. Energy

| | |
|---|---|
| Fossil fuel consumption | Provided data was accurate, in liters. |
| Electricity for tunnels and lighting | Provided data was accurate, in kw/h. |
| Electricity for buildings | Provided data was accurate, in kw/h. |
| Refrigerant fluds | The data was not available. What is significant in this quantity is the leek or the refilling of refrigerant fluid (R22, R134a, etc.). It was assumed that this was one of the smaller contributions in GHG emissions (less than 0,5% of total). |

Table 2. Freight

| | |
|---|---|
| Intern freight | No specific data available, but it has a small contribution and was not considered at all. |
| Incoming freight | The input is a comprehensive list of deliveries that includes type of goods, km traveled for each delivery, number of deliveries, and transportation mode. The weight of each mode (in veh.km) was estimated. |

Table 3. Passenger transportation

| | |
|---|---|
| Home-work travels by employees | The data was accurate: transportation mode and km travelled for each employee for an average day, and then, assuming the year has 225 working days, we were able to calculate the annual distance travelled. |
| Outside travels by employees | The data was accurate: we had a list of trips, with the number of employees, destination and route, as well as the type of carriers. We were able to estimate passenger.km by carrier. |
| Office vehicles | The data was accurate and we were able to input total liters of fuel. |
| Travels by visitor | The data was accurate. |

Table 4. Incoming materials and services

| | |
|---|---|
| Office supplies | The input was a very large list of supplies. We ran some tests that ensured that this item was a very low contributor to the total GHG emissions. For example, even if we assumed that all of the supplies were very emitting, their contribution to the carbon footprint of the company would be less than 1% of the total. |
| Purchased services | Some of the data referred to distance travelled or quantities of goods. Those could be processed directly. Other services needed an extra calculation: according to the number of hours and the level of skill needed, we estimated the amount of the services. We took an average cost of 25€/h. We did not take into account the travelled distance of some companies (landscaper, recovery, fire brigade, ambulance). |

Table 5. Amortizations

| | |
|---|---|
| Infrastructure, computer equipment and vehicles | Some datas are missing : specifications of heavy equipments such as ventilators or generators (tons of material), tons of the 18km-long noise barriers, tons of painting. Nevertheless, most of the emissions of this item are due to the infrastructure itself (pavement and barriers). This data could be improved, especially as regards the infrastructure, but it would not change the priorities. It could be useful to be more precise only if the company were committed to an ambitious low carbon strategy implying upgrades of the infrastructure. |

Table 6. Waste

| | |
|---|---|
| Identified waste and scrap | The input was a detailed list of recycled waste, with the respective weights. These were all divided into categories, depending on their components. For example, a fire extinguisher is 90% steel and 10% plastic. Out of 15 types of waste, we could deal with 12. The 3 that were not taken into account were toner, hazardous waste and batteries. Composition of scrap was estimated to be 95% paper, 2,5% aluminum and 2,5% plastic. In addition, over 2300 m3 of waste were being disposed in 2009 (230 bins of 10m3). It has been estimated that 7% of it was forwarded to certified recycling companies, and we took the same estimation as we did for the composition of scrap<br>The rest of the waste – 4 417,7 tn – was sent to landfill. |

Table 7. Road Traffic

| | |
|---|---|
| Quick estimation | Average daily traffic in 2009: 307 300 vehicles.<br>Average km : 15 km<br>Total: 1 682 467 500 vehicle.km every year.<br>Assuming that it would be only light vehicles, and only taking into account the consumption of fuel and not the amortization of the car, we set a very low 150g.$CO_2$-e / vehicle.km. It represents a minimum of 250 000 t.$CO_2$-e over the year. A more detailed calculation would prove to have a much higher contribution to the carbon footprint of the company. |

## 6. Results

From the analysis that followed, it was established that almost 50% of the total carbon emissions from the company's activities were a result of energy consumption, in terms of electricity and fuel, while another 30% resulted from passenger and freight transportation.

| Emission Source | % of total emissions |
|---|---|
| Energy | 49% |
| Transportation | 30% |
| Amortizations | 18% |
| Supplies | 2% |
| Direct waste | 1% |
| Freight | >1% |

To understand the main contributors to emissions in each of the categories/, we will briefly analyse each emission source, to identify the key contributors. This is useful when trying to organize a strategy towards GHG emission reduction. "If you cannot measure it, then you cannot reduce it" is the general principle behind carbon assessment. The whole purpose is to be able to take measures that will bring about a $CO_2$ reduction; it is not to come up with a precise number that gives you the $CO_2$ total, it would be unrealistic to try and measure everything precisely. After all, the whole analysis will always be based on assumptions. When something cannot be measured, then we simply cannot take it into consideration, as it would be something that could not be changed in any way, to lead to the reduction of the carbon footprint.

*6.1. Energy (49%)*

Considering the highest source of GHG emissions, which is energy consumption, we can see that almost all emissions come from the use of electricity. Lighting is the main contributor to electricity consumption and hence, is a main candidate for investigation for reduction.

| Emissions due to energy consumption | % of total emissions due to energy |
|---|---|
| Electricity supply | 92% |
| Loss of electricity | 7% |
| Consumption of fuel | 1% |
| Upstream emissions of fuel | 0% |

*6.2. Transportation (30%)*

The vast majority of this type of emission is due to the employees. Traffic and maintenance works account for nearly 90% of the transportation emissions, as can be seen in the table that follows:

| Emissions due to transportation | % of total emissions due to transportation |
|---|---|
| Professional, car and trucks | 89% |
| Commuting | 10% |
| Professional, plane | 1% |
| Visitors | 0% |
| Professional, bus | 0% |

*6.3. Amortization (18%)*

The infrastructure accounts for 95% of this type of emissions. This offers little possibility of optimization, as regards a road operator's activities.

| Emissions due to amortization | % of total emissions due to amortization |
|---|---|
| Roads | 59% |
| Safety barriers | 21% |
| Buildings | 16% |
| Tools and machines | 3% |
| Computer equipment | 1% |

*6.4. Other Emissions (3%)*

The remaining 3 sources of emissions have a very small impact on total $CO_2$ emissions altogether, but it is worth identifying the main contributors in each case, nonetheless.

| Emissions due to supplies | % of total emissions due to supplies |
|---|---|
| Services | 54% |
| Chemicals | 38% |
| Paper | 8% |
| **Emissions due to waste** | **% of total emissions due to waste** |
| Landfill waste | 97% |
| Recycled waste | 03% |
| **Emissions due to freight** | **% of total emissions due to freight** |
| Incoming freight | 100% |

## 7. Reduction Targets and further actions

After the completion of the calculation of the carbon footprint for 2009, the company was able to identify the main contributors to GHG emissions. Based on this information, the company then proceeded to set goals on emission reduction for the following years, and decided on which actions to take to reduce these emissions.

The mitigation measures that were selected mainly involved energy and fuel consumption. As a first measure, for 2010, it was decided to install new light-sensors and meters upstream of tunnel entrances to control lighting levels in the tunnels and along the open motorway. Although operation of these new systems was implemented towards the end of 2010, it resulted in energy savings in the order of 20% for the first months, hence leading to the reduction of the carbon footprint of Attica Tollway, while also contributing to cost savings. In addition, the company renewed its vehicle fleet, purchasing newer and less fuel-consuming vehicles.

As carbon assessment for 2009 was our first attempt to evaluate our emissions and understand how the process works, we then went into the process of re-organizing how the various pieces of information were provided by the different departments of the company. The goal was to standardize the way the information was supplied, so that it took less time to input the data into Bilan Carbone® and evaluate the carbon footprint for following years. This delayed, as expected, setting actions and goals for 2010 and having enough time to act upon these goals.

As a result, for the calculation of the carbon footprint for 2010, we decided to calculate the difference that our (minor) changes -with respect to our vehicle fleet constitution and lighting conditions for open road and tunnels- have made in our carbon footprint. We only took electricity consumption and fuel for heating and vehicles into consideration, assumed all other sources of $CO_2$ to be the same (as we had no major changes in personnel, furniture etc) and came up with a saving in the order of 1 ton of $CO_2$ compared to 2009, which makes sense, as major electricity consumption reduction methods only came into force in December, while the changes in our vehicle fleet are too many to be able to identify the benefit yet.

The full effect of these changes (more effective lighting and more diesel-powered vehicles) will be more evident in 2011, since in a sense, 2009 and 2010 were almost identical. Carbon assessment for the year 2011 will have more impressive results, along with the full effects of eco-driving and switching to newer and less fuel-consuming patrols and the company is looking forward to quantifying these and planning more for the years to come.

## 8. Conclusion

For these new efforts towards measuring and reducing our carbon footprint, Attica Tollway Operations Authority received a Certificate of Merit in the “Green Leader – MyClimate Awards”, organized by the Centre for Sustainability and Excellence for the first time in Greece in 2011. We are still on a steep learning curve with respect to carbon assessment, but the first initiative has been taken and we are enthusiastic and willing to learn. Compared to our first attempt to calculate the carbon footprint, we have already speeded-up the process of data collection and soon, we expect to make carbon assessment a very straight-forward and quick process, leaving more time to plan future actions and goals.

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